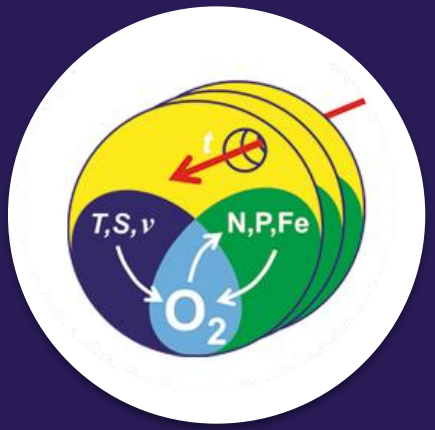
GEOMAR
Helmholtz Centre for Ocean Research Kiel



Atlantic Equatorial Deep Jets

Sven-Helge Didwischus, Peter Brandt, Richard Greatbatch

Special thanks to John Toole and Leah Trafford (WHOI)
for providing and processing MMP data

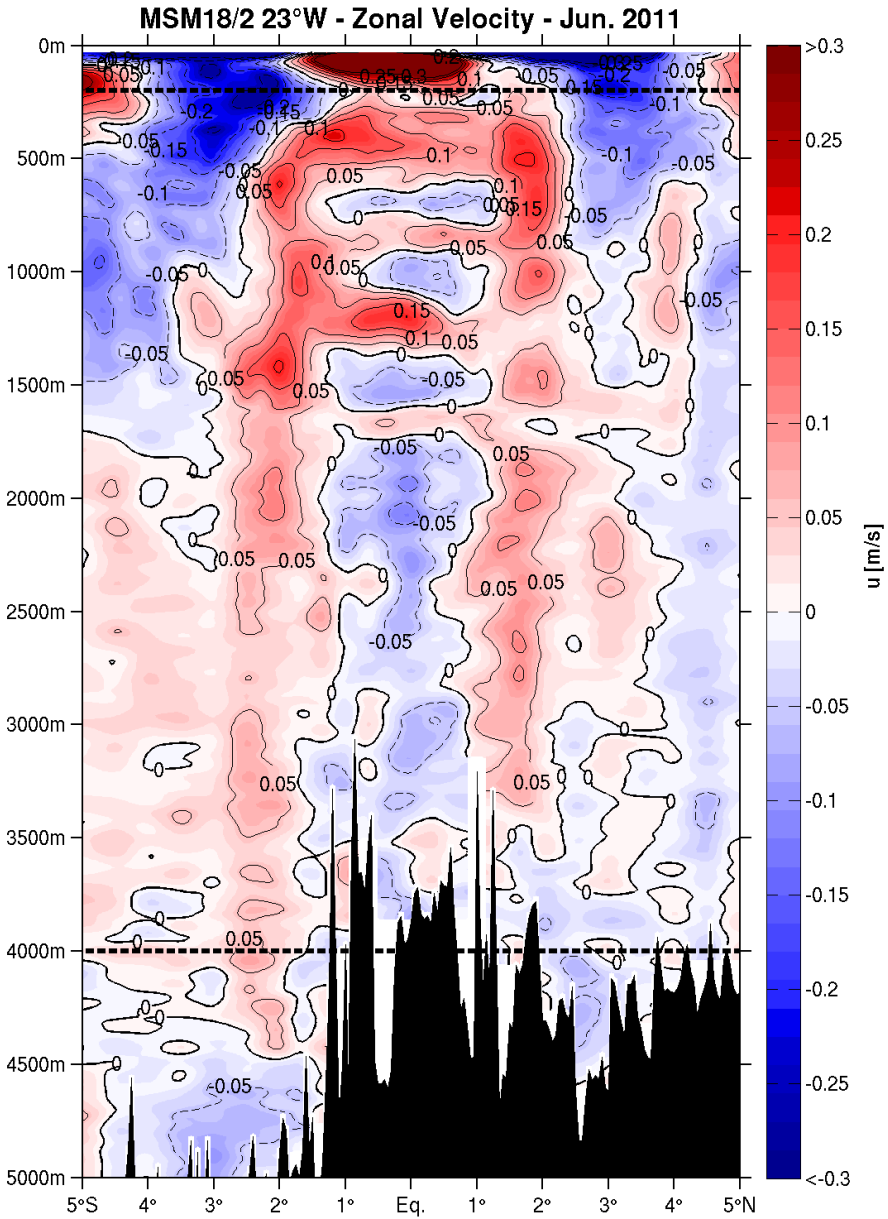
11.09.2012

Tropical Atlantic Variability Meeting, Kiel, Germany

Motivation

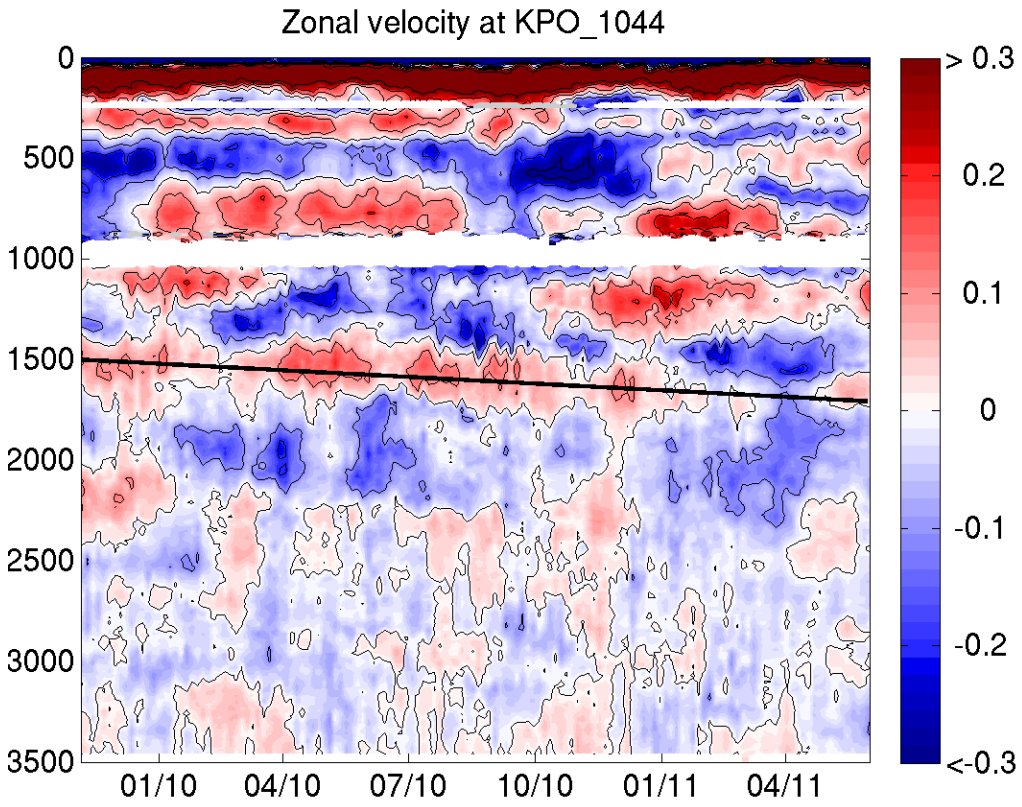
Equatorial Deep Jets

- Alternating zonal currents at the equator with up to 0.3m/s
- Below EUC to ~2500m depth
- Focused on the equator bounded by extra equatorial jets (Gouriou et al. 2001)
- Zonal extent close to basin width
- Small vertical wavelength
- Measured in all 3 equatorial oceans



Equatorial Deep Jets

- 4.5yr period in the Atlantic
  (Brandt et al. 2011;
  5±1yr, Johnson & Zhang 2003;
  4.4yrs, Bunge et al. 2008)
- Period fits to a basin mode
- EDJs can be measured in zonal velocity and in strain
- Vertical propagation of 132m/yr (Johnson & Zhang 2003)

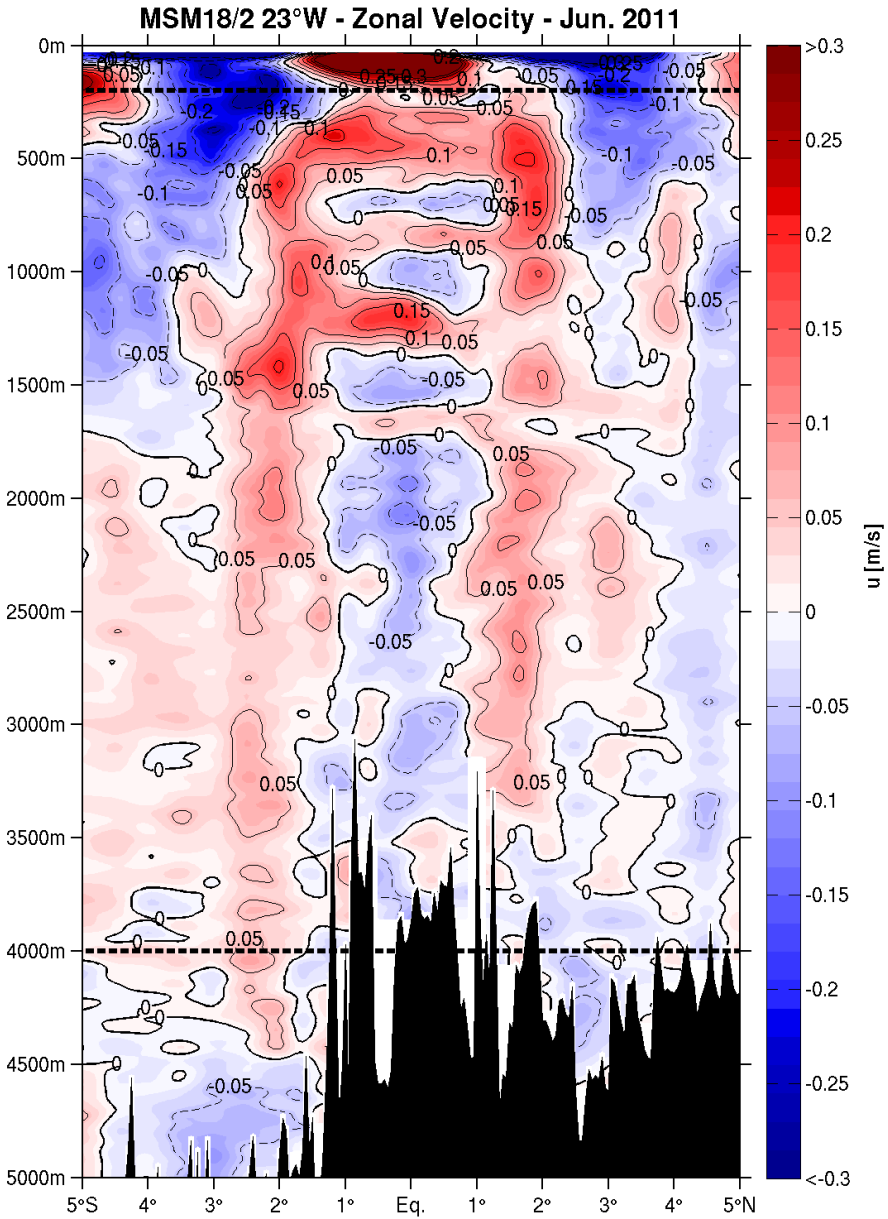


Motivation

Equatorial Deep Jets

- Structure and mechanisms are not completely understood
- Models do not really reproduce EDJs
- Zonal transport of water masses by EDJ quite unclear

➢ 3 independent datasets used to get a better picture of the structure



Atlantic Equatorial Deep Jets

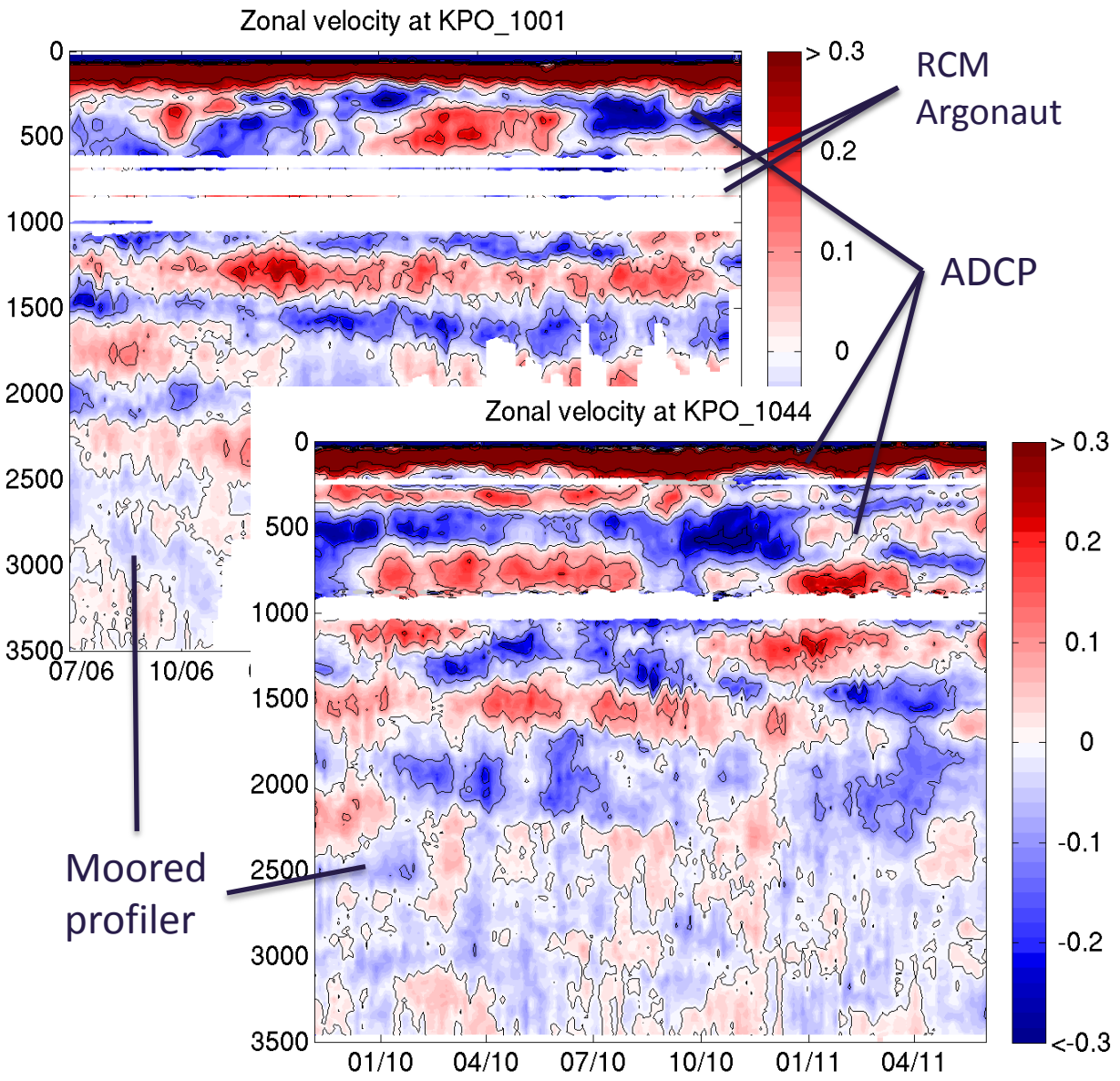
Data

Mooring Data:

In collaboration with
John Toole (WHOI)

23°W:

- KPO_1001, equator
  June 2006 – Feb. 2008
- KPO_1043, 0.75°S
  Nov. 2009 – June 2011
- KPO_1044, equator
  Nov. 2009 – June 2011

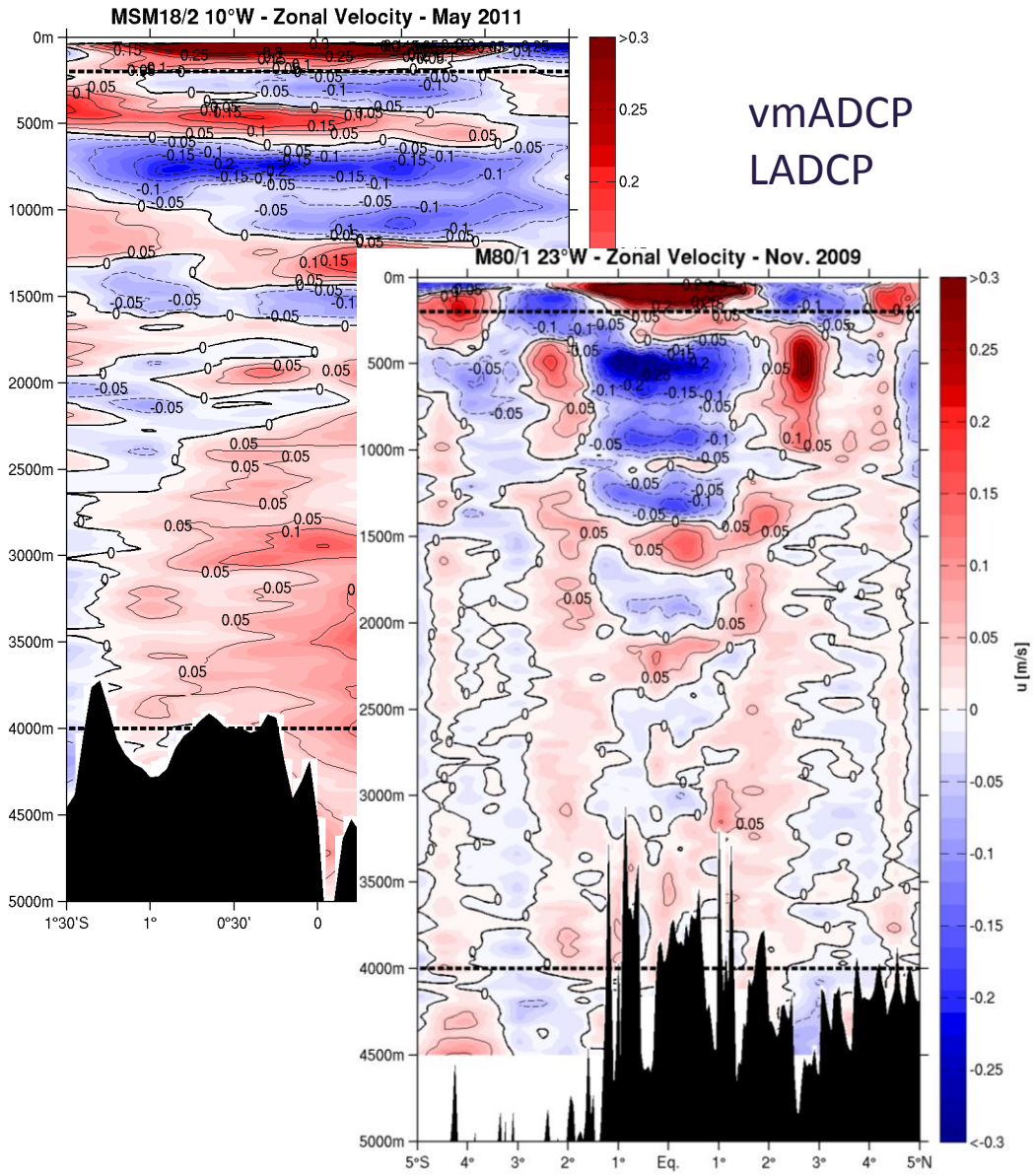


Atlantic Equatorial Deep Jets

Data

Deep cross equatorial ship sections

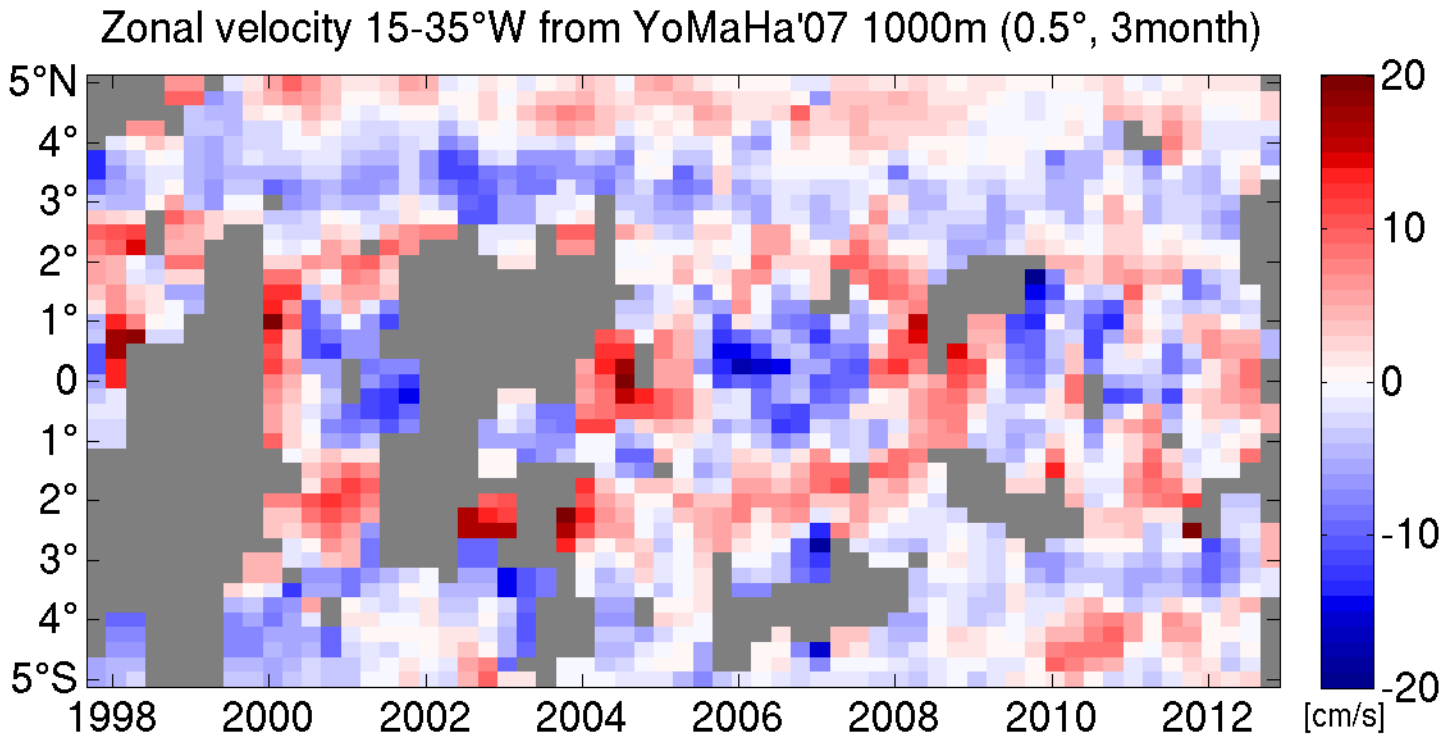
- 23°W:
  4 sections
  1999 - 2011
- 35°W:
  5 sections
  1999 - 2003
- 10°W:
  1 section
  2011



Data

YoMaHa'07 (Lebedev et al. (2007))

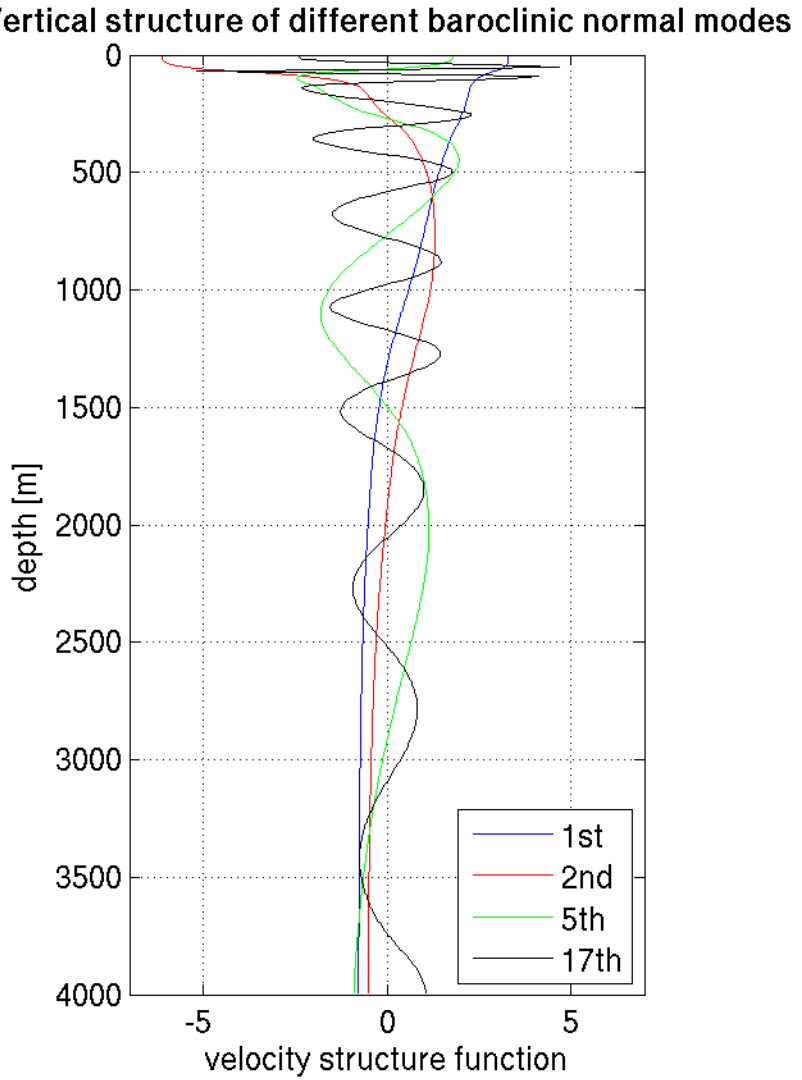
- Drift data from Argo floats
- Floats with parking depth at 1000m
- 15 - 35°W, 5°S – 5°N



Vertical structure of EDJs

- Vertical structure function of baroclinic normal modes calculated from mean CTD profile
- First 40 modes fitted to data
- Modes used as vertical length scale
- EUC left out
- No real orthogonality of modes due to gaps in data
  100 runs with different random order of modes fitted

- Squared amplitude → mode energy



Atlantic Equatorial Deep Jets

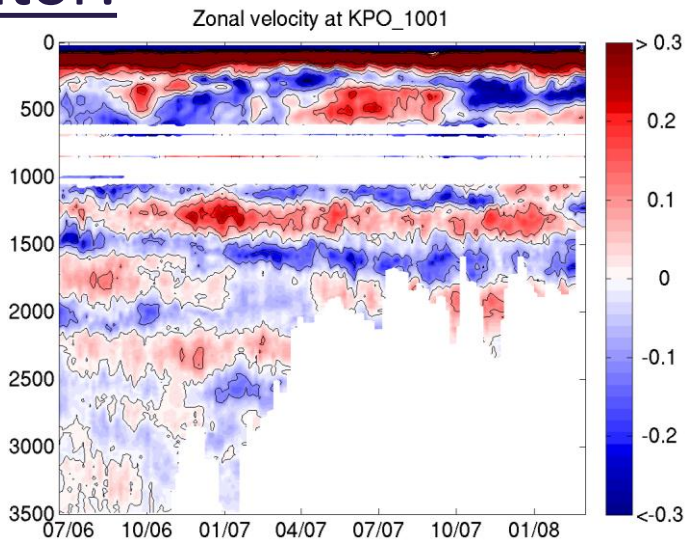
Vertical structure

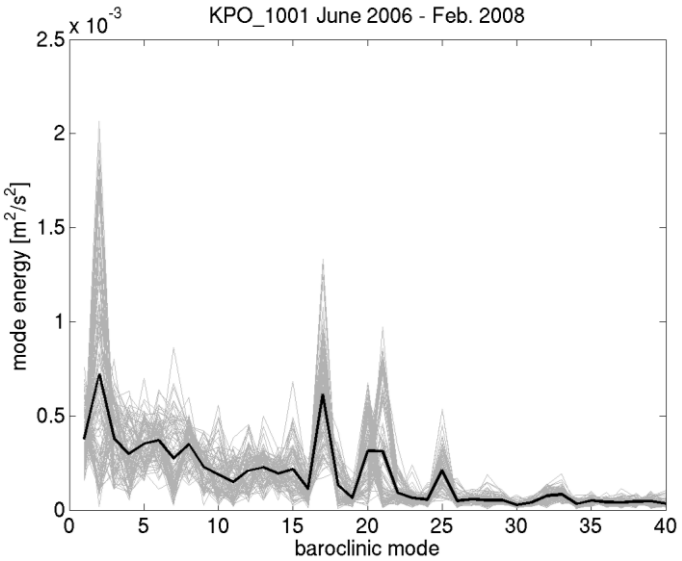
23°W, equator:

KPO_1001

June 2006 – Feb. 2008

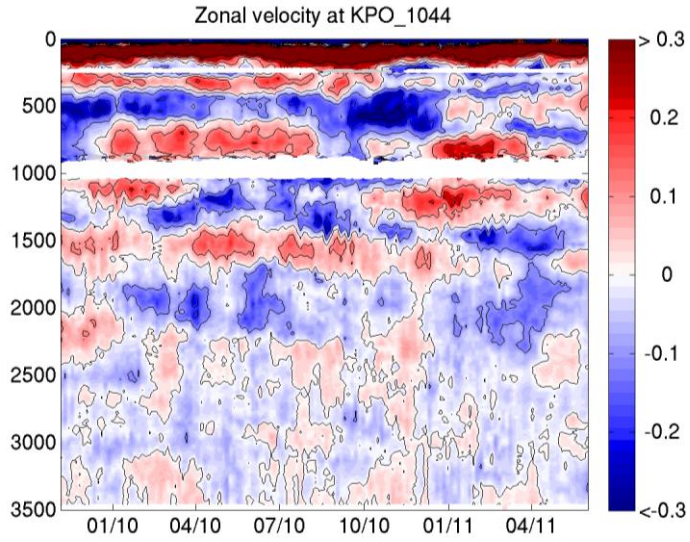
Only first part is used, >80% data (June – Oct. 2006)

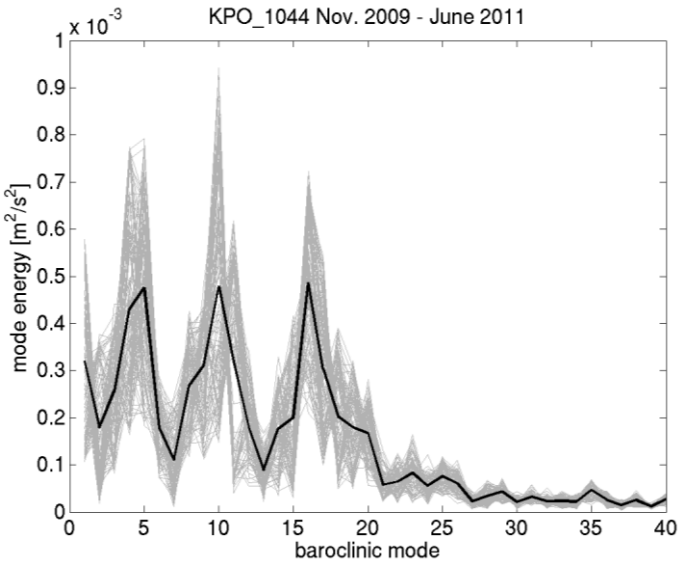




KPO_1044

Nov. 2009 – June 2011

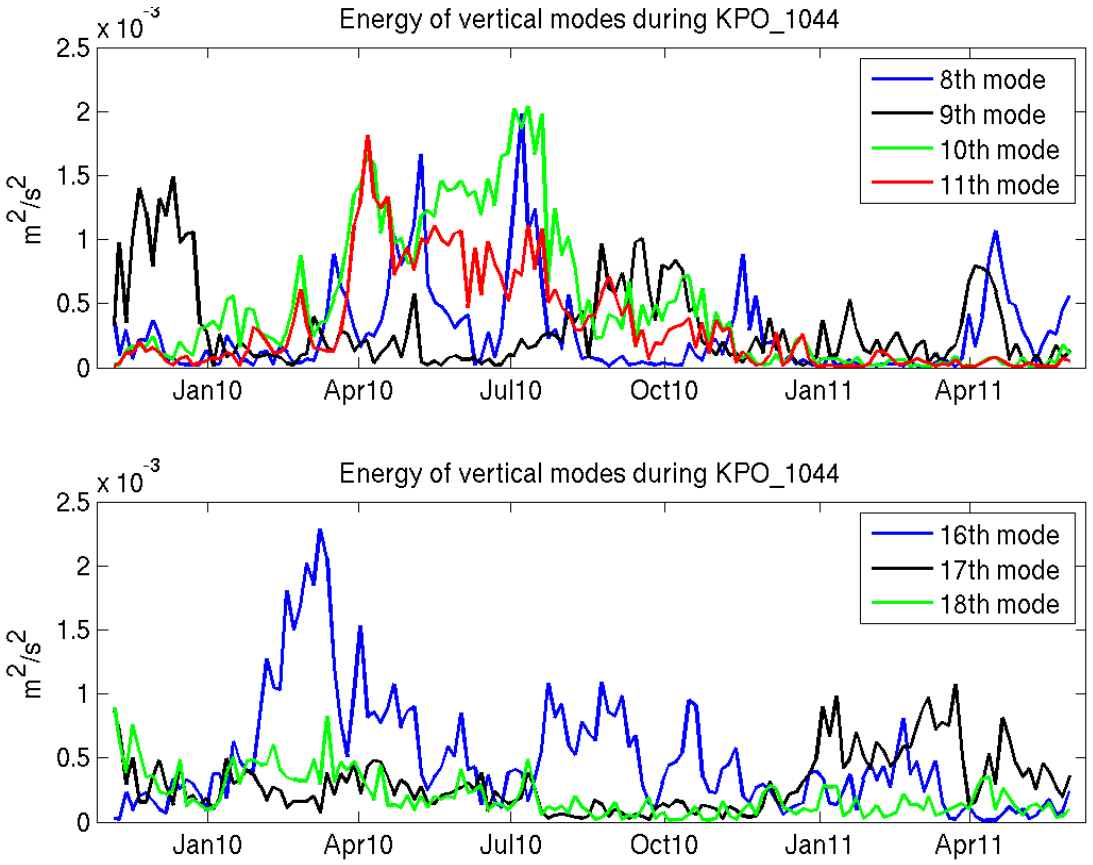




Atlantic Equatorial Deep Jets

Vertical structure

- Mode composition is changing with time
- More baroclinic modes involved
  - needed for vertical propagation of EDJs



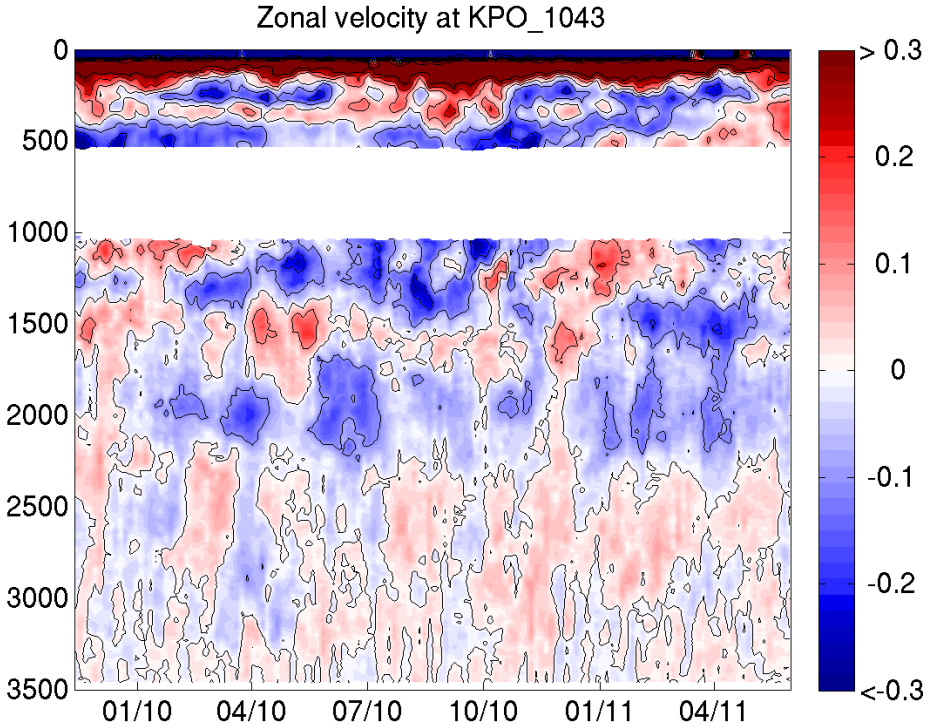
Atlantic Equatorial Deep Jets

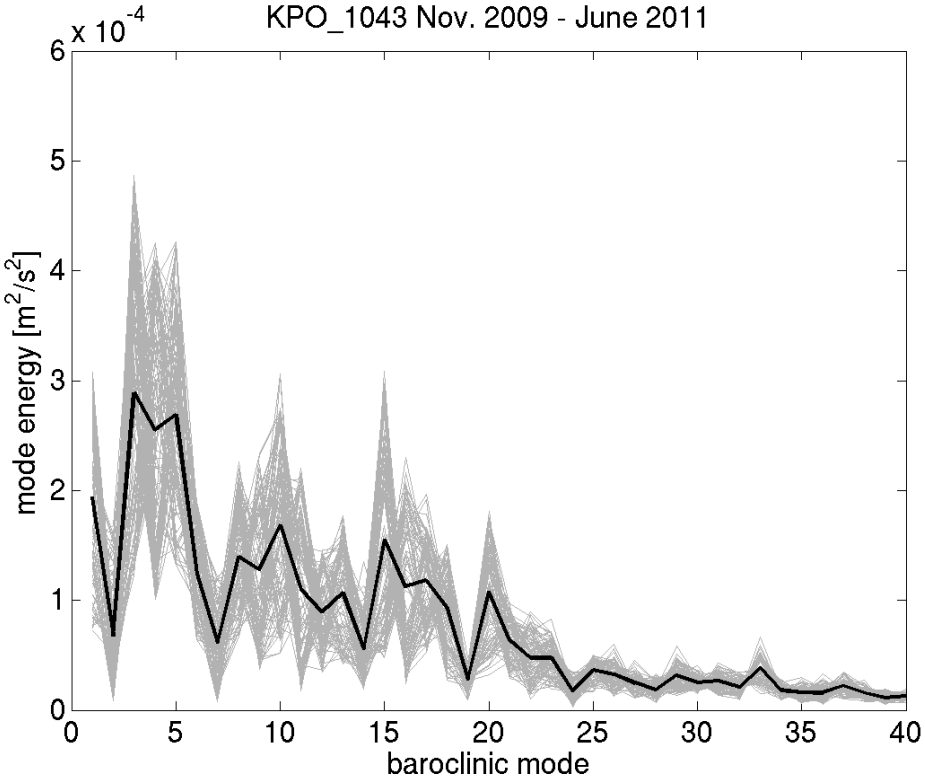
Vertical structure

KPO_1043

23°W, 0.75°S

Nov. 2009 – June 2011

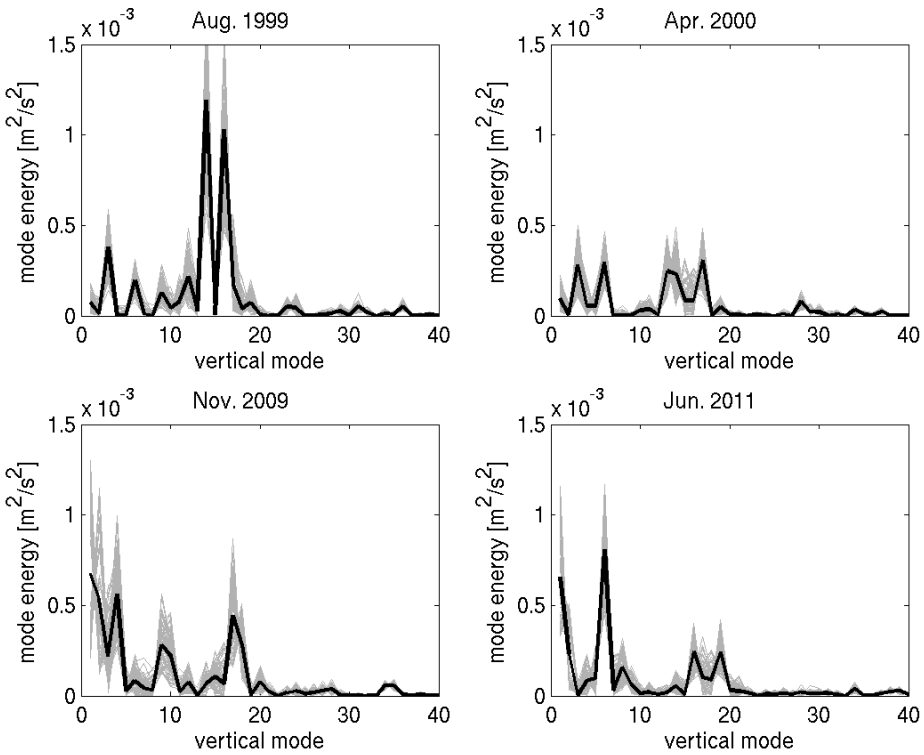


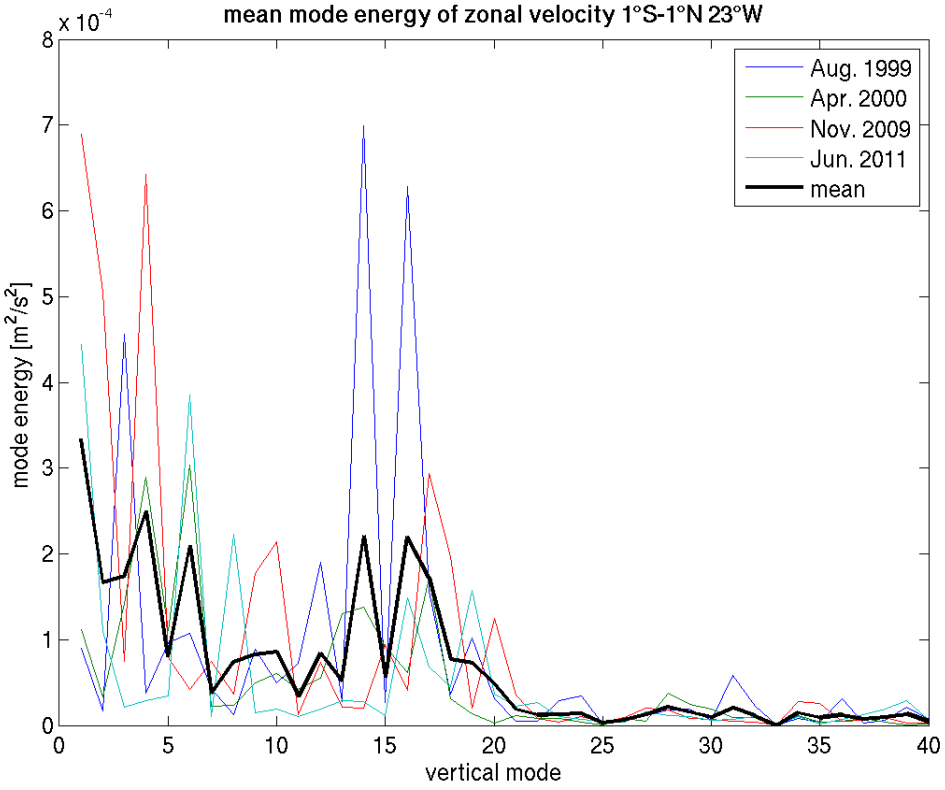


Atlantic Equatorial Deep Jets

Vertical structure

23°W cross equatorial sections

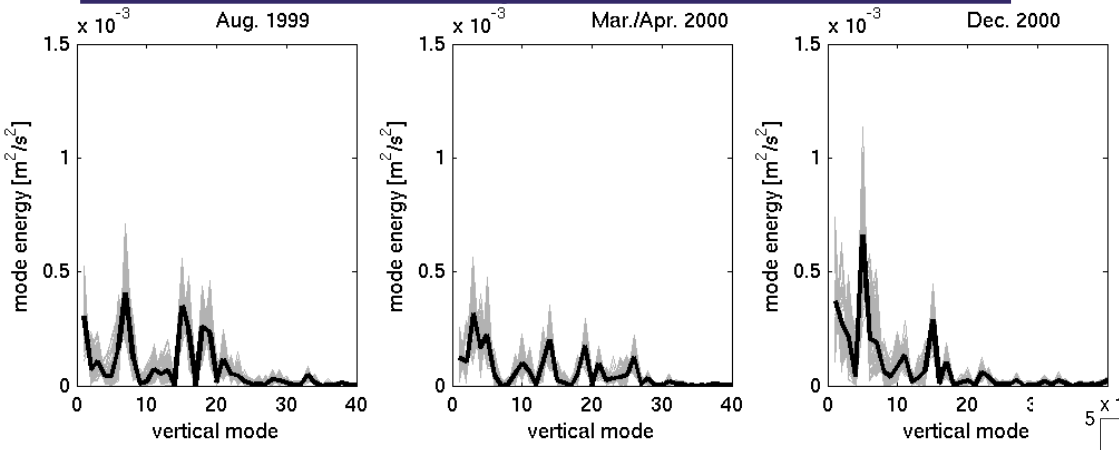


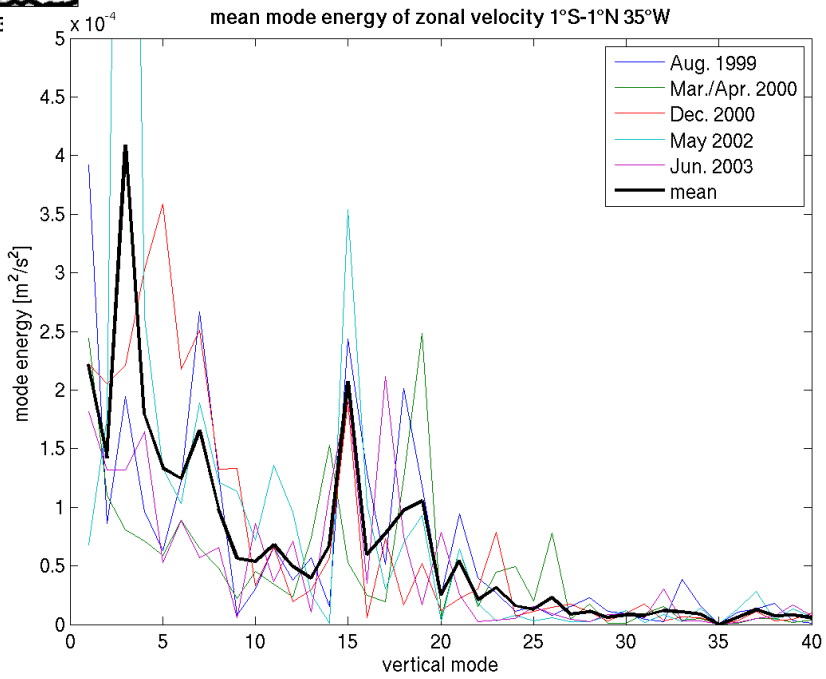


Atlantic Equatorial Deep Jets

Vertical structure

35°W cross equatorial sections

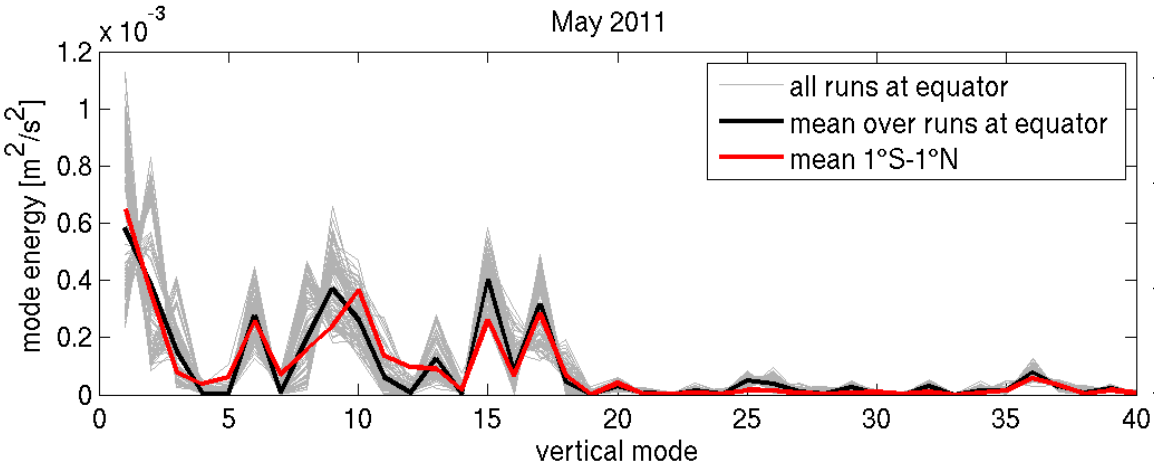


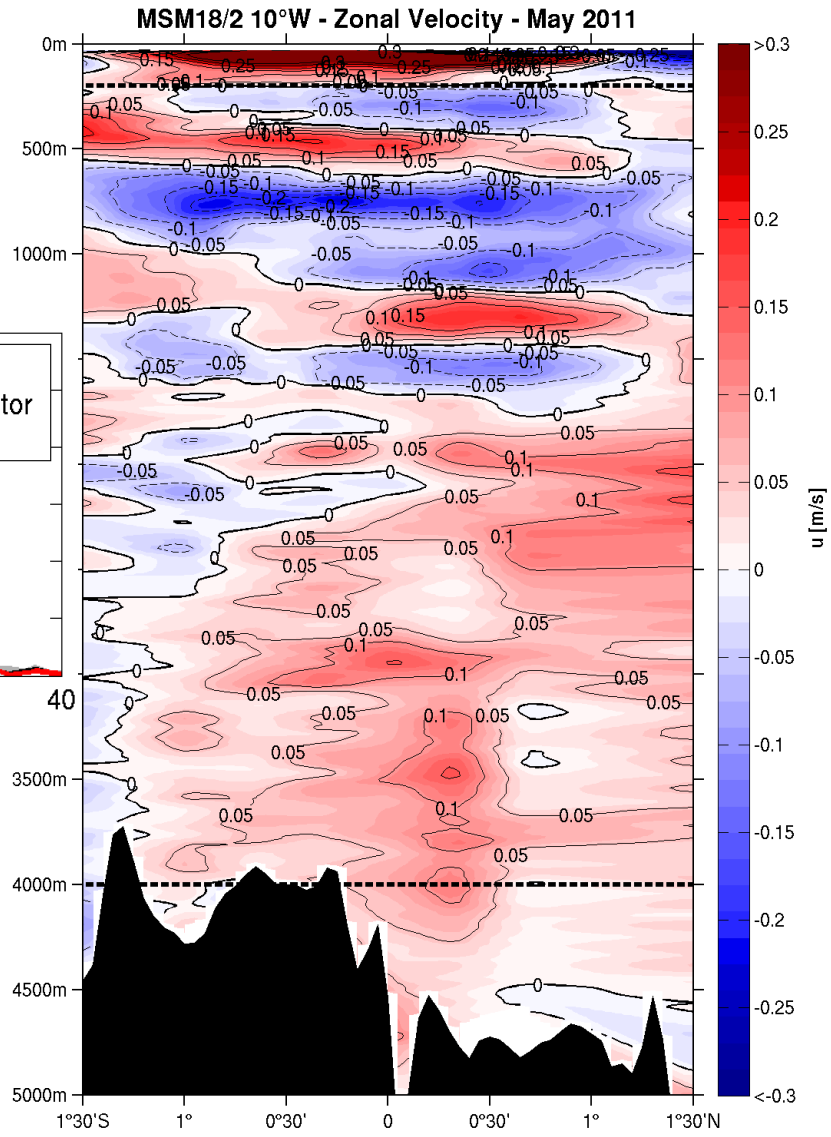


Atlantic Equatorial Deep Jets

Vertical structure

10°W cross equatorial section





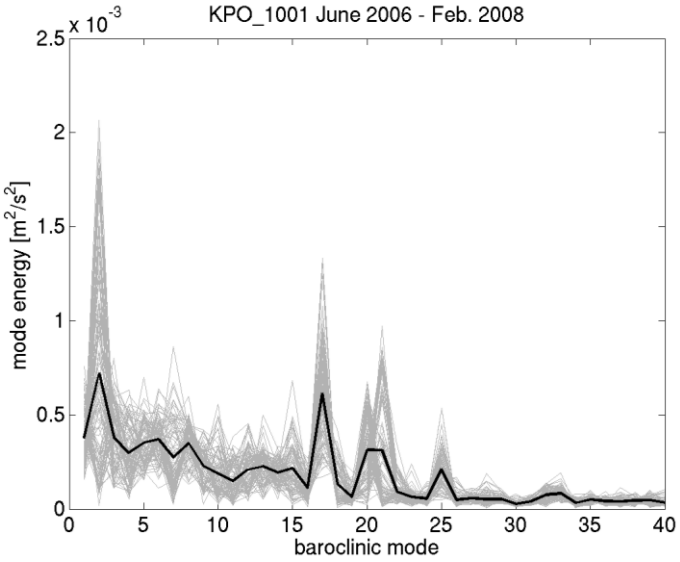
Only one section available by now
MSM 18/2 – May 2011

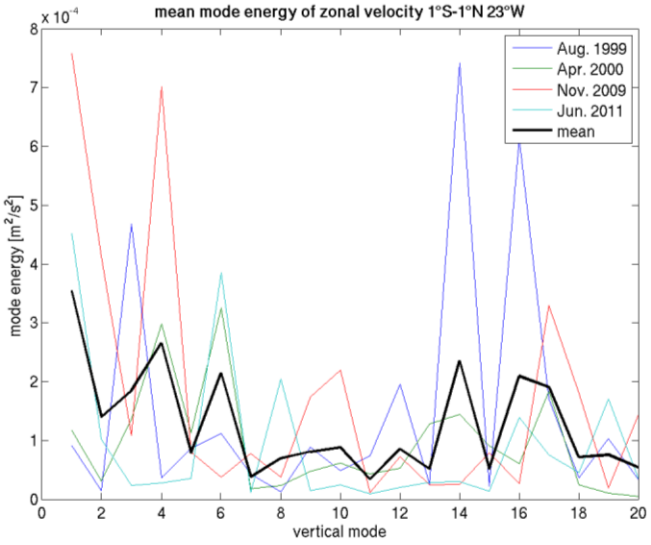
Atlantic Equatorial Deep Jets

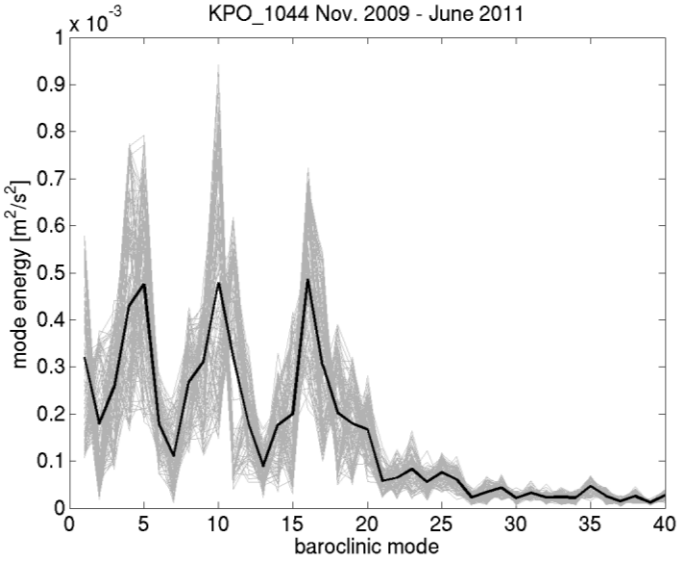
Vertical structure

3 types of maxima

- Low baroclinic modes
  → shorter periods
- Around 10th baroclinic mode
  → needs more tests
- 14th – 21st baroclinic mode
  → EDJs







Meridional structure of EDJs

Estimated in two different ways:

- Cross equatorial ship sections:

  meridional structure of amplitude and energy of vertical modes

- YoMaHa Argo float data:

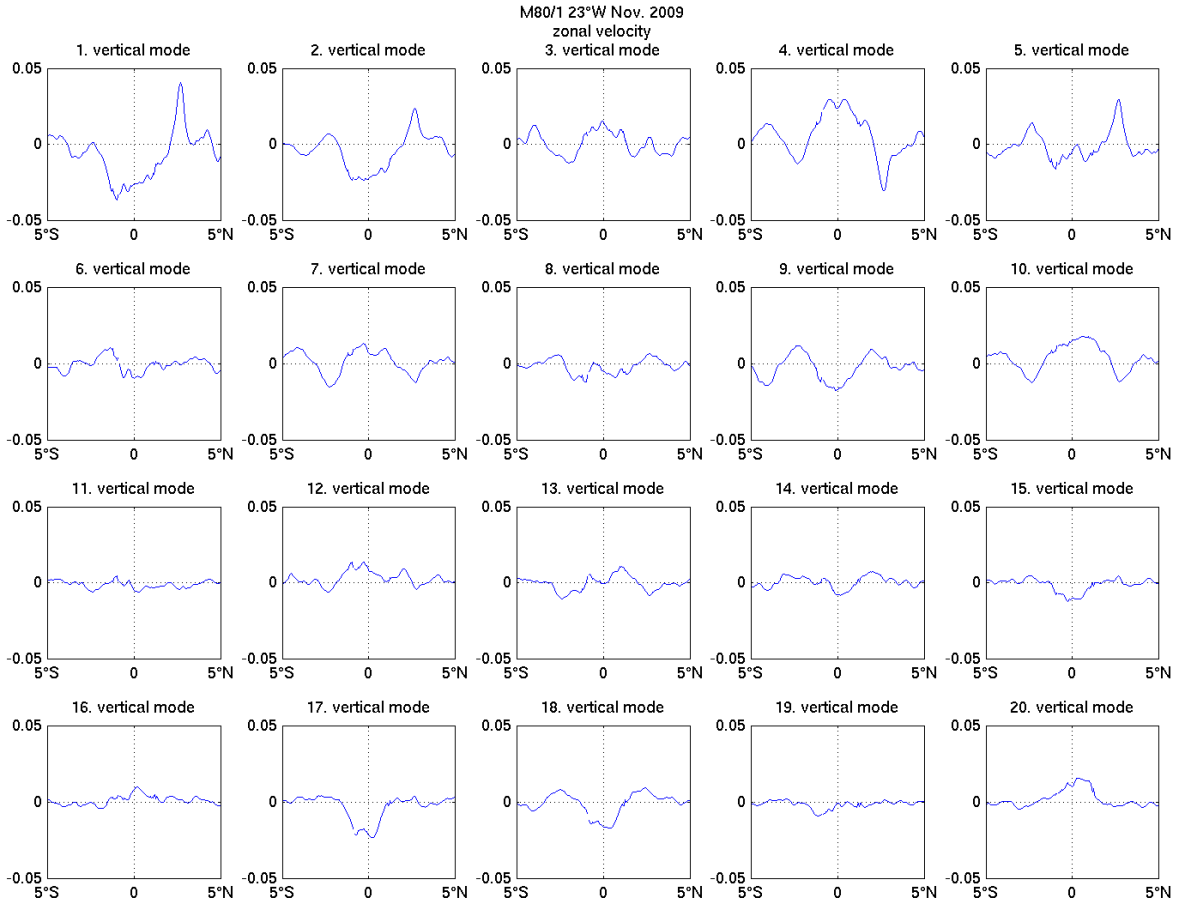
  meridional structure of amplitude and energy of 1670d harmonic fit

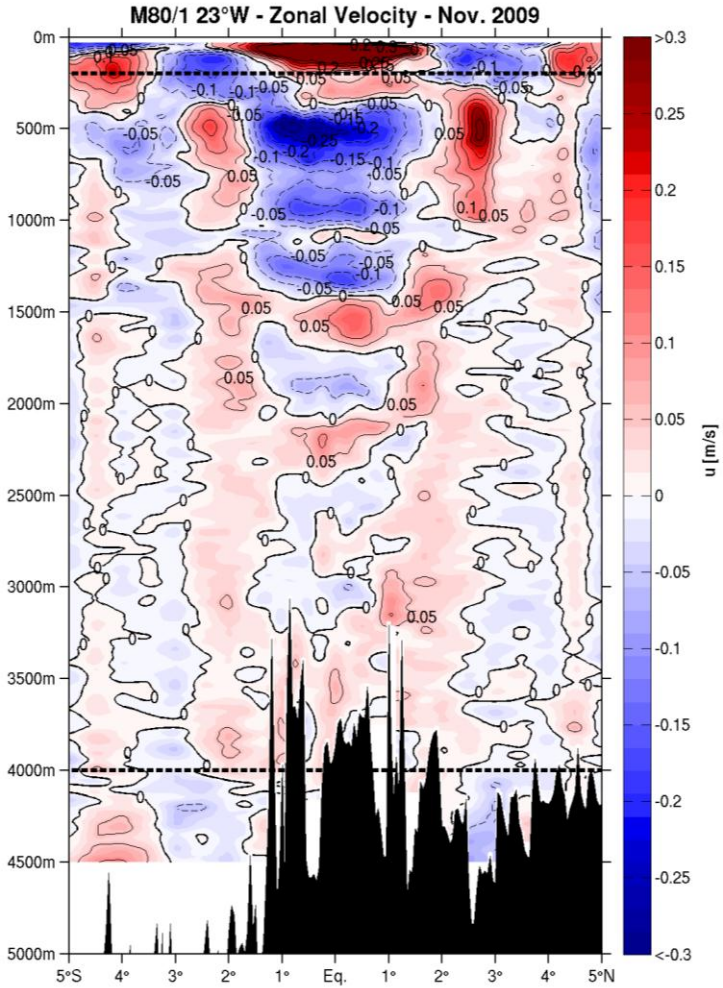
Atlantic Equatorial Deep Jets

Meridional structure

Meridional structure of amplitude of baroclinic modes

M80/1
Nov. 2009

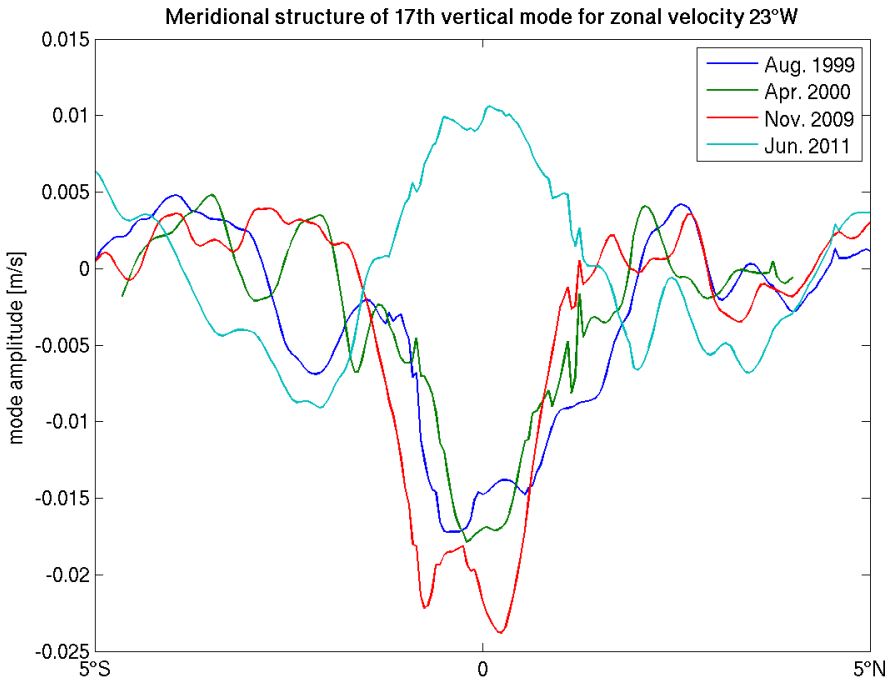




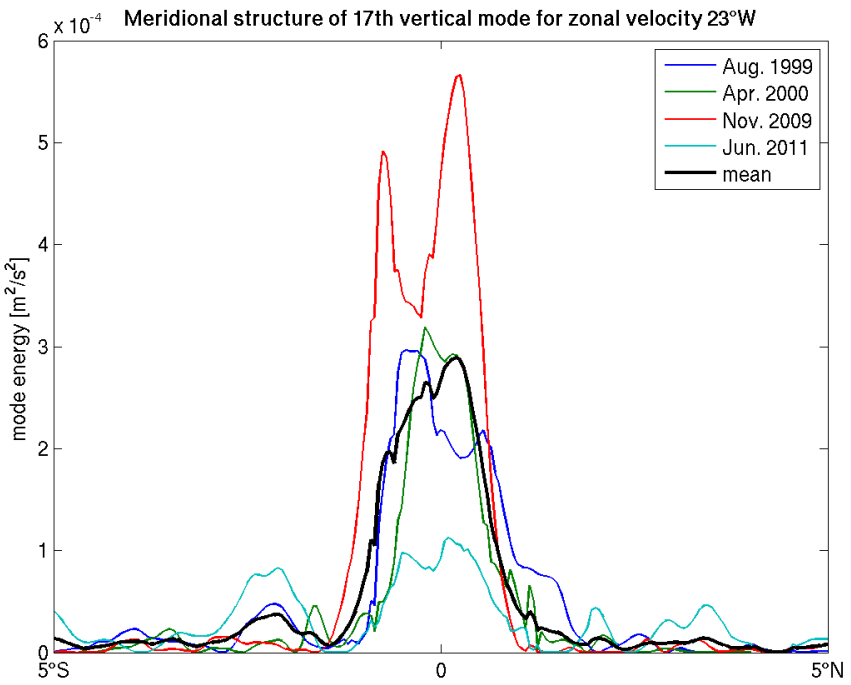
Meridional structure

Meridional structure of 17th baroclinic mode

amplitude



energy



First 3 sections are nearly in EDJ phase

Last section is in opposed phase

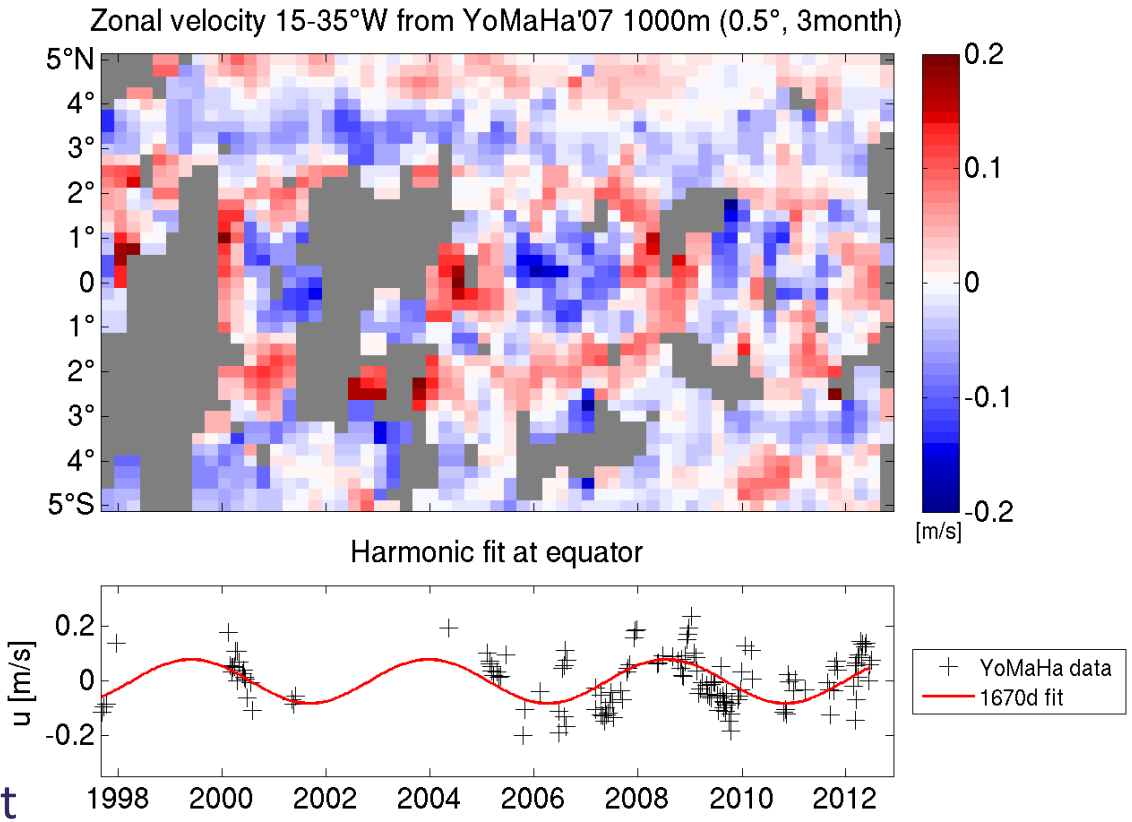
Atlantic Equatorial Deep Jets

Meridional structure

YoMaHa'07 (Lebedev et al. (2007))

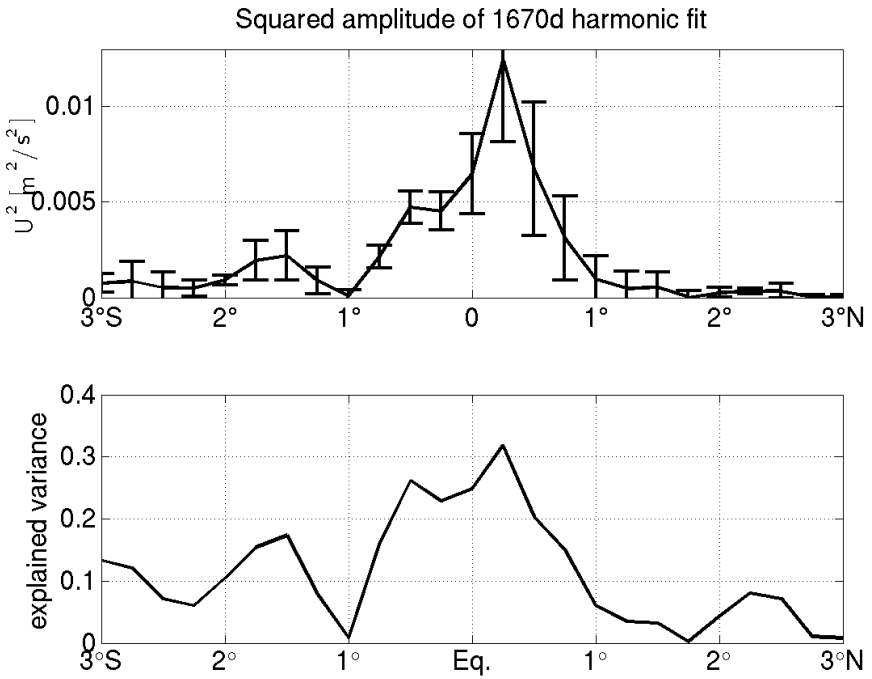
- Box 15° – 35°W, 5°S – 5°N
- Data separated in time series for 0.5° meridional bands
  assumption: zonal EDJ wavelength is much wider than box
  → nearly in same phase
- 1670d harmonic fitted to data

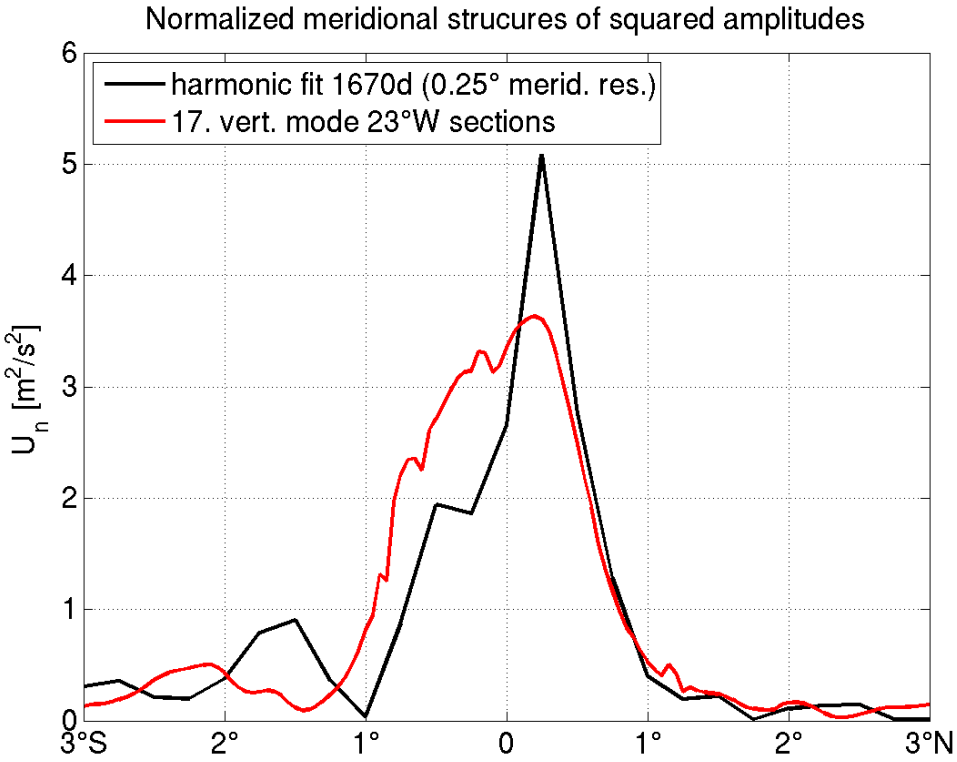
  1670d period was determined using different datasets (moorings, YoMaHa)



Atlantic Equatorial Deep Jets

Meridional structure





- Two completely different ways of calculation
  - Ship sections: depth-latitude information
  - YoMaHa: time-latitude information

→ comparable meridional structure

Results:

Vertical structure:

- Maxima at about 14th to 21st baroclinic mode can be associated with EDJs
- Maximum around 10th mode has to be checked
- Energy of modes is variable in time

Meridional structure of EDJs:

- Vertical mode and time series analysis both lead to a comparable meridional structure

- See next talk for further analysis of these structures

END

Thank you for your attention!

References & Acknowledgements

Acknowledgements:

Thanks to

John Toole (WHOI) for providing moored profiler data from equatorial moorings.

Leah Trafford (WHOI) for processing MMP data.

This study used the data of YoMaHa'07 [Lebedev et al., 2007] dataset of velocities derived from Argo float trajectories and provided by APDRC/IPRC.

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Brandt, P., A. Funk, V. Hormann, M. Dengler, R.J. Greatbatch and J.M. Toole, 2011: Interannual atmospheric variability forced by the deep equatorial Atlantic Ocean, Nature, 473, 497-501, doi: 10.1038/nature10013

Gouriou, Y., et al., 2001: Deep circulation in the equatorial Atlantic Ocean. Geophysical Research Letters, 28 (5), 819–822.

K. V., Lebedev, H. Yoshinari, N. A. Maximenko, and P. W. Hacker. YoMaHa'07: Velocity data assessed from trajectories of Argo floats at parking level and at the sea surface, IPRC Technical Note No.4(2), June 12, 2007, 16p.

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